Overnight Heart Rate Variability Depends on Age, Gender, and Day of the Week: A Field Observation Using a Smart Bed Platform

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INTRODUCTION

- Variability in heartbeat timing, or heart rate variability (HRV), is used to assess the activity of the autonomic nervous system (ANS).[1]
- Changes in ANS function are reflected in HRV and result from lifestyle factors, aging, cardiorespiratory illnesses, and physiological stress.[2]
- Despite broad interest in HRV, few studies have characterized overnight HRV values or unobtrusively measured HRV during sleep in a large population.
- Previous results have shown an age-related decrease in HRV in both an extensive sample of 20- to 60-year-old Fitbit™ wearers[3] and a sample of 260 healthy individuals.[4] Further, these studies showed that:
  - HRV declines with age for both men and women.
  - For individuals under the age of 50 years, the effect of male/female gender on HRV was mixed across the 2 studies.
  - The effect of gender on HRV disappears by age 50 years.[4]
- The standard deviation of normal-to-normal intervals (SDNN) is one of several types of HRV time-domain measures used to quantify the variability in measurements of time intervals in between successive heartbeats.[5]
  - Normal-to-normal intervals are interbeat cardiac intervals that represent normal cardiac timing and are free from artifact.
- When measured for 24 hours, the SDNN may be used to stratify patients into different risk categories for cardiac-related morbidity and mortality.[5]
- To better understand population-level HRV changes, ecologically valid, overnight sleep SDNN values were analyzed for a large sample of Sleep Number™ smart bed users who provided electronic consent to be contacted to participate in scientific research.

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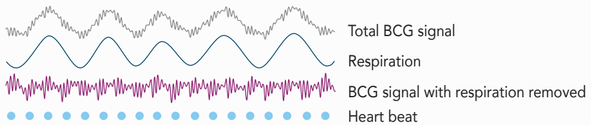
METHODS

- Overnight SDNN values were obtained from Sleep Number™ smart bed recordings from home users in an ecologically valid research environment.
  - The time interval for SDNN measurement depended on the user and sleep session.
- Heartbeat intervals used to compute SDNN were extracted from a ballistocardiogram (BCG; **Figure 1**).
- BCG-based HRV measurement was previously tested in our laboratory for correlation with electrocardiogram (ECG)-based HRV, and these measures were found to be positively correlated, with a coefficient of determination (R^2) of 0.50.

FIGURE 1: SIGNALS OBTAINED FROM THE SMART BED PLATFORM

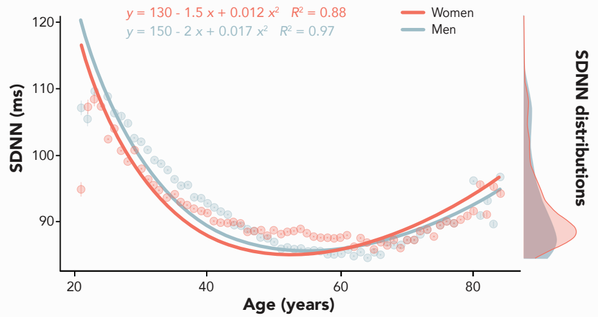


BCG, ballistocardiogram.

RESULTS

- Overnight SDNN values were obtained over the course of 18.2M sleep sessions from 379,225 users (48 ± 14.7 sessions/user).
- The study cohort was 50.9% women.
- The ages of the cohort ranged from 21 to 84 years and followed a normal distribution with a mean age and standard deviation of 52.8 ± 12.7 years old.
- Using a generalized linear model, statistically significant trends in SDNN were observed for several variables of interest: age ($P < .0001$), gender ($P < .0001$), and weekday vs weekend ($P < .0001$).
  - The interaction of age and gender was significant ($P < .0001$).
- As depicted in the model (**Figure 2**):
  - SDNN declined at a rate of approximately 2.1 ms/year for users under 50 years of age, leveled off for users 50-65 years of age, and subsequently increased.
  - Women under 50 years of age displayed lower, more slowly declining SDNN values than men. This trend reversed for users over 50 years of age.

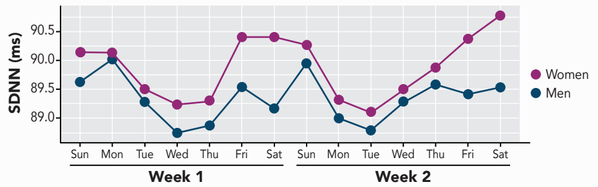
FIGURE 2: GENERALIZED LINEAR MODEL FOR THE EFFECT OF AGE AND GENDER ON SDNN



Each point represents a mean SDNN value and its standard error for a given age. Lines represent predicted SDNN values based on the corresponding models shown.
SDNN, standard deviation of normal-to-normal intervals.

- SDNN values followed a cyclical pattern each week for both men and women, with values peaking over the weekend and reaching a nadir midweek (**Figure 3**).

FIGURE 3: WEEKLY CYCLES IN SDNN FOR MEN AND WOMEN



SDNN, standard deviation of normal-to-normal intervals.

CONCLUSIONS

- We used smart bed technology to measure overnight SDNN values unobtrusively among a large-scale set of users in an ecologically valid environment.
  - Our analysis revealed significant effects of age, gender, and day of the week on overnight SDNN values.
- Starting at age 65 years, SDNN values increased with age.
  - This trend contrasted with previously reported SDNN levels for healthy individuals aged 65 years or older, whose SDNN levels decreased over time.[3]
- Differences in gender were apparent for some, but not all, age groups:
  - For those aged 40 years or younger, men had consistently higher SDNN values than women.
  - For those aged in their 50s, women had consistently higher SDNN values than men.
- Weekend SDNN values were significantly higher than weekday values, suggesting that sleep may be more restorative in the absence of weekday stressors and time constraints.

REFERENCES

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DISCLOSURES

SB, **KS**, **GGM:** Employees of Sleep Number Corporation.

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